Prototype Self Sensing, Intelligent Multifunctional Nano-enhanced Structures

Completed Technology Project (2013 - 2014)

Project Introduction

SmallSats and CubeSats are the latest generation of small, lightweight spacecraft envisioned to accomplish significant scientific missions. In view of the limited mass, volume and power resources available, optimized electronics packaging at the component, subsystem and spacecraft levels present significant design constraints. *Prototype Self, Sensing Intelligent Multifunctional Nano-enhanced Multi-Functional Structures* is a multi-year effort to develop appropriate hardware to enable board level 3D electronics packaging as well as advanced thermal control for power electronics, RF subsystems and solar panels.

Electronics packaging is a complex technology development issue that requires coordinated optimized solutions at the component (chip), subsystem (board) and system (spacecraft/instrument) levels. The proposed effort will develop intelligent structural-thermal capabilities embedded into a multi-functional structure. Embedded electrohydrodynamic (EHD) thermal control subsystem will enable lighter, more compact packaging capable of greater heat transport than the current state of the art (conduction and radiation). Future spacecraft electronics subsystems may contain electronics components directly integrated into the board at a greater component density (more components) than currently possible due to thermal constraints. This structure will ultimately reduce the number of boards required (mass and volume savings). Furthermore, convective, two-phase embedded thermal control subsystems significantly reduce the overall thermal resistance and will allow remote heat rejection at higher temperatures than those currently attained by electronics thermal control packages. The spacecraft realizes significant mass and volume savings with smaller, more effective radiators.

Additive manufacturing techniques are advanced manufacturing processes that build up a structure or device layer by layer. Additive manufacturing processes have not yet been applied to multifunctional structure applications. The self-sensing thermal/strain system will require a material with homogenous electrical and thermal properties as temperature and strain will be measured using resistivity. Furthermore, the thermal subsystem will require small channel hydraulic diameters. Each of these subsystems will be directly integrated at the 'layer' level determined to provide for optimal structural and thermal performance. Thus, candidate materials include both metals and nano-enhanced polymers whose properties can be engineered to meet project requirements. These requirements are ideal for multifunctional structures: strict manufacturing tolerances, small-scale features, and advanced materials. The investigation at hand will advance additive manufacturing techniques and processes by combining self-sensing (temperature-stress/strain), complex embedded thermal hardware (EHD electrodes), structural capabilities, wiring board and grounding plane into a single, homogenous device.

Prototype Self Sensing, Intelligent Multifunctional Nano-enhanced Structures

Table of Contents

Project Introduction 1
Anticipated Benefits 2
Primary U.S. Work Locations and Key Partners 2
Organizational Responsibility 2
Project Management 2
Technology Maturity (TRL) 2
Project Website: 3
Technology Areas 3

Center Independent Research & Development: GSFC IRAD

Prototype Self Sensing, Intelligent Multifunctional Nano-enhanced Structures

Completed Technology Project (2013 - 2014)

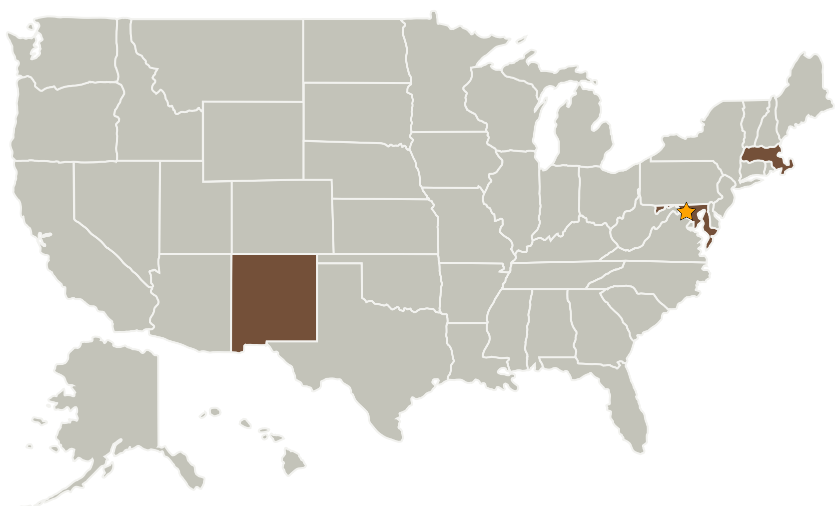
Anticipated Benefits

This is a cross cutting technology to improve the overall size, weight and power metrics of spaceccraft of all sizes. The focus is on smaller spacecraft form factors, such as CubeSats and SmallSats.

Intelligent, optimized structural-thermal subsystems for reduce size, weight and power: RF, power electronics, spacecraft structure, and electronics busses.

Intelligent multifunctional structures are important to aerospace, space and terrestrial applications. The hardware developed on this project finds applications to structural-thermal subsystems for defense (land, sea and air) as well as civilian applications (power electronics and electronics packaging).

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland
Air Force Research Laboratory / Space Vehicles	Supporting Organization	US Government	Kirtland AFB, New Mexico

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:

Peter M Hughes

Project Manager:

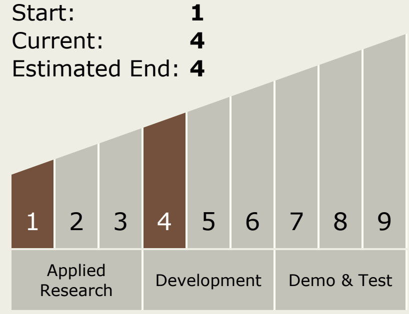
Theodore D Swanson

Principal Investigator:

Jeffrey R Didion

Technology Maturity (TRL)

Start: **1**
Current: **4**
Estimated End: **4**



Prototype Self Sensing, Intelligent Multifunctional Nano-enhanced Structures

Completed Technology Project (2013 - 2014)

Co-Funding Partners	Type	Location
Air Force Research Laboratory / Space Vehicles	US Government	Kirtland AFB, New Mexico
University of Maryland-College Park(UMCP)	Academia	College Park, Maryland
Worcester Polytechnic Institute	Academia	Worcester, Massachusetts

Primary U.S. Work Locations	
Maryland	Massachusetts
New Mexico	

Project Website:

http://aetd.gsfc.nasa.gov/

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  └ TX12.2 Structures
    └ TX12.2.5 Innovative, Multifunctional Concepts